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NUCLEAR WINTER: IMPLICATIONS FOR US AND SOVIET NUCLEAR
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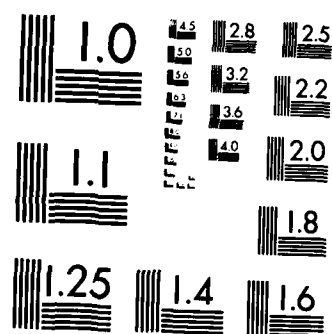
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NUCLEAR WINTER: IMPLICATIONS FOR
U.S. AND SOVIET NUCLEAR STRATEGY

Philip J. Romero

December 1984

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I. INTRODUCTION

In November 1983 Dr. Carl Sagan and his colleagues reported to the press on the results of their study of the atmospheric consequences of nuclear war. The TTAPS¹ study found that for a wide range of possible U.S.-Soviet nuclear exchanges, including relatively small ones, the fires from nuclear detonations would inject into the stratosphere quantities of dust and soot that would obscure sunlight for months. Under the cloud, which would spread over most of ~~the~~ Northern Hemisphere, temperatures might drop scores of degrees, well below the freezing point of water; thus, "nuclear winter." The TTAPS team's findings suggested that the consequences of a nuclear war might be even more gruesome than previously supposed, and the long-term climatic and biological results might be nearly as severe for a war of 100 megatons as for 5,000.

Sagan's press conference launched a debate that has been notable for rhetoric and extreme position-taking on both sides. For example, at about the same time that the TTAPS findings were first published in *Science* magazine,² Sagan also authored a policy-oriented article in *Foreign Affairs* in which he recommended reduction of the strategic arsenals of the U.S. and Soviet Union to something under a thousand warheads each, as a matter of "elementary planetary hygiene, as well as elementary patriotism."³ He goes on to say:

The problem cries out for an ecumenical perspective that rises above cant, doctrine and mutual recrimination, however apparently justified, and that at least partly transcends parochial fealties in time and space. What is urgently required is a coherent, mutually agreed upon long-term policy for dramatic reductions in nuclear armaments and a deep commitment, embracing decades, to carry it out.⁴

¹ The acronym derives from the names of the authors: R.P. Turco, O.B. Toon, T.P. Ackerman, J.B. Pollack, and C. Sagan.

² Turco, R.P., et. al. "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions," *Science*, 23 December 1983, pp. 1283-1292.

³ Sagan, Carl. "Nuclear War and Climatic Catastrophe: Some Policy Implications," *Foreign Affairs*, Winter 1983/84, p. 286.

The detractors of nuclear winter have been at least as vituperative though much more private in their denunciations.⁵ Many scientists' and analysts' positions about the nuclear winter findings have already hardened. The supporters of TTAPS imply in their public statements that acceptance of its findings is a litmus test of the public's attitudes about nuclear war (are you for it or against it?). Some critics have suggested that to them TTAPS is a denunciation of U.S. strategic deterrence policy, present and past.

From the point of view of informing policymakers and the public concerning the consequences of wars involving nuclear weapons, the politicization of the nuclear winter issue is unfortunate. We can hope that in the next few years the criticism and defense of the initial TTAPS work will give rise to significant additional analyses, to illuminate the question. Realistically, further study will probably include both confirmations and contradictions of the original findings, without necessarily "resolving" the issue. Sadly, the surrounding political atmosphere may obstruct sober consideration of the policy implications of *the possibility of nuclear winter*.⁶

The purpose behind this paper is to stimulate some longer-range thinking about the consequences for U.S. national security *assuming* "nuclear winter" was generally believed to be true. The author has made no attempt to evaluate the validity of the TTAPS findings and will not comment upon them in this paper. The paper assumes for the sake of hypothesis generation that the broad outlines of TTAPS stand up to further scrutiny and asks the "what-if" question: "Suppose the national

⁵ *Ibid*, p. 292.

⁶ At the time of this writing (late May 1984), no extensive criticism of TTAPS or the policy recommendations of its authors had yet appeared in public. (For a review by meteorologists who accepted the quantities of soot particles (2×10^{14} grams) calculated by Sagan and independently calculated the effects of cloud dispersion, see Covey, Schnieder, and Thompson, "Global Atmospheric Effects of Massive Smoke Injections from a Nuclear War: Results from General Circulation Model Simulations", *Nature*, March 1984.)

⁶ The National Research Council is currently under sponsorship by the Defense Nuclear Agency to perform a reassessment of the possible climatic effects of nuclear war.

leaderships of the nuclear nations believed that an 'above-threshold'⁷ nuclear war would cause nuclear winter.⁸ How might their concepts of *prosecuting* a nuclear conflict change?" The focus of the paper will be on changes in war *strategies*, whose consequences would promote changes in missions for some strategic forces, as well as changes in their targeting and basing over the next twenty to twenty-five years. It may be possible to make a very crude assessment of nuclear winter's implications for U.S. national security by evaluating the relative abilities of the U.S. and the Soviets to *adapt* to the new "strategic reality," considering the major differences in the force structures and security requirements of the two countries.

The forecast of this potential future is "bounded" via several key assumptions about the next twenty-five years. First, there are no major changes in basic East-West antagonisms. Second, there are no radical reductions in weapons or launchers; that is, Sagan's recommended arms control is not adopted.⁹ Third, U.S. and Soviet doctrine and force structure *preferences* do not significantly deviate from historical trends. The point of these assumptions is to stress that while belief in nuclear winter can *eventually* overturn strategies and force postures, in the past U.S. nuclear planning at least has been remarkably resilient in the face of great changes in declaratory policy and official doctrine. Even if nuclear winter implied sweeping changes, they will be evolutionary--i.e., there will be no "overnight revolutions" in doctrines or force postures. For the next five to ten years, at least, strategy will largely be based on the weapons and the bases we have today.

⁷ The "threshold," which Sagan estimates as very roughly 100 megatons or 500-2000 warheads, is discussed in Section II.

⁸ Alternatively, they might *not* fully believe it, but be unwilling to accept the risk of being wrong. Therefore, they might choose to hedge.

⁹ Sagan's recommendations are contained in Sagan, op. cit., pp. 286-292. Such a general arms reduction would certainly not be without its risks, either. For example, in a world where the aggregate number of nuclear weapons was 500 (the bottom of Sagan's threshold), the covert manufacture of even a few dozen would augment a nation's relative power much more than today. Hence, the incentives for building or acquiring such weapons by motivated developing countries might increase.

Following a brief summary of the TTAPS findings in Section II, Section III will discuss the evolution of nuclear strategy at three points in time: roughly five, ten and twenty years from now. It does not consider possible changes in the roles of non-strategic nuclear forces, general purpose forces, or small nuclear powers. Finally, Section IV summarizes the tentative hypotheses suggested and notes the implications of potential asymmetries in U.S. and Soviet abilities to adapt.¹⁰

¹⁰ It should be mentioned that this portrait of a possible future, like all topical forecasts, is bound to overlook influences, outside the boundaries of the inquiry, which in the end often exert a much more profound influence on events than the issue under consideration. For instance, it would be difficult to find a discussion of ICBM vulnerability from the mid 1970's which predicted that ICBM basing would become such a divisive issue that ultimately MX missiles would be placed in existing silos, in part to minimize political cost. Similarly, this paper excludes the possibility that policymakers would simply ignore nuclear winter, even though they believed in its validity.

II. NUCLEAR WINTER: SUMMARY OF EFFECTS DESCRIBED BY TTAPS¹

The novel features of the TTAPS study's findings stemmed from three nuclear weapons effects that had not been explored in detail in previous studies:

- A. Large-yield weapons that are *ground burst* may produce on the order of 300,000 tons of *dust* per megaton exploded. If the weapon has a yield of more than a few hundred kilotons, the cloud will reach a height sufficient to carry this dust into the stratosphere.
- B. Weapons burst on *city centers* may produce *firestorms* of such intensity that the fireball will rise up into the stratosphere. Particulate matter in the form of *soot and smoke* will rise with it--approximately two million tons per megaton detonated on the city center.
- C. Once in the stratosphere (and possibly the upper troposphere as well, depending upon temperature conditions), the particles will be carried by wind currents to spread throughout the mid-latitude belt of the Northern Hemisphere, and possibly the Southern Hemisphere as well. The particles can stay at these altitudes for *weeks to months*.

The consequences are illustrated in Table 1, based upon figures reported in Sagan's *Foreign Affairs* article, which shows the extent to which this enormous cloud would reduce sunlight arriving on the surface, causing the earth to cool. The first of the two least severe TTAPS scenarios is Case 11, a counterforce exchange of 3000 megatons in which 2,250 weapons are targeted against isolated military sites. The dust

¹ This section sketches only a very brief summary of the causes and consequences of nuclear winter. A more extensive discussion can be found in Turco (fn. #2), summarized in Sagan (fn. #3) and Ehrlich, Anne: "Nuclear Winter," *Bulletin of the Atomic Scientists*, April 1984, pp. 1S-15S.

Table 1

PRINCIPAL TTAPS SCENARIOS AND THEIR ESTIMATED EFFECTS

	CASES				
	14. 100-MT Counterurban	1: Baseline; Mixed Counterforce and Counterurban	11. "Nominal" Parameterization, Counterforce	16. "Severe" Parameterization, Counterforce	17. "Severe" Parameterization, Mixed Counterforce & Counterurban
Total Yield (Megatons)	100 MT	5,000 MT	3,000 MT	5,000 MT	10,000 MT
% Yield Urban/ Industrial Targets	100%	20%	0%	0%	15%
% Yield Surface Bursts	0%	57%	50%	100%	63%
Max. Reduction of Average Northern Hemisphere Temperature - Degrees C (Approximate)	-35 C	-36 C	-8 C	-38 C	-60 C
Days after Detonation of Max. Temperature Reduction (Approximate)	20 days	25 days	80 days	110 days	70 days
Temperature Reduction after 300 Days - Degrees C (Approximate)	0 C	-4 C	-4 C	-23 C	-22 C

produced is almost entirely generated by those 50 percent of the weapons which are ground-burst. Case 14 is a 100 MT attack on city centers, airbursting 1000 weapons. Here the blockage of sunlight is due to smoke and soot produced by firestorms. Note that while the initial amount (and absorbancy) of particles is greater in the counterurban case, producing temperature drops of approximately 35 degrees Centigrade, much of that soot precipitates out of the atmosphere through rain beginning within a few weeks, returning the surface to normal temperatures after about four months. By contrast, the counterforce Case 11 injects much more dust, which apparently is much less light-absorbent than soot resulting in a much smaller decrease in temperature. However, that dust remains within the stratosphere, and precipitates only very gradually over the course of years.

Table 1 shows three other attacks as well. The Case 1 baseline is a mixed 5,000-megaton urban/military attack using 10,400 weapons. According to the TTAPS analysis reported by Sagan, for most of the first three months the temperature effects of this large attack are virtually indistinguishable from Case 14, the cities-only attack. This seems to be the basis for Sagan's observation that "these climatic results are very independent of the kind of war we're talking about."² Cases 17 and 16 are "severe" excursions. In case 17 the size of the attack is increased, and in Case 16 especially severe estimates of the density of combustible material and the size of the burned area are used.

The biological effects of such a sudden and sustained drop in light and temperature are discussed in Ehrlich's companion *Science* article.³ The reader can draw his own inferences about the ability of people and ecosystems to sustain themselves under the circumstances, with inland water frozen, plants unable to photosynthesize, etc.

The "robustness" referred to by Sagan is actually at least partly due to the parameterization of the two cases to which he referred (Case 1, a 5000 MT urban/military exchange, and Case 14, a 100-MT attack on city centers), in particular through variations in the assumptions about

² Ehrlich, A., *op. cit.*, p. 55

³ Ehrlich, Paul, et al., "Long-Term Biological Consequences of Nuclear War," *Science*, 23 December 1983, pp. 1293-1300.

the density of combustible material in cities that would produce smoke and soot. This may be why Sagan declines in his *Foreign Affairs* article to declare that a 100-megaton exchange will necessarily be the "threshold" above which climatic effects will be severe. Rather, he opts for a broader range of between 500 and 2000 strategic warheads.⁴ Below and above this range, "climatic catastrophe"⁵ is respectively "not at known risk" or "expected," and inside the range climatic catastrophe is "risked."

Because this 500-to-2000 weapon threshold is well inside the sizes of both superpowers' arsenals, and eventually those of several other nuclear nations as well, Sagan recommends drastic cuts in arsenals to be implemented over many years. He comes to this conclusion after reviewing and rejecting several alternatives, such as lower-yield, highly accurate weapons, which he describes as "the perfect post-TTAPS first-strike weapon."⁶ Sagan discounts the possibility of wars remaining below the threshold (primarily because of the risks of escalation). Thus, in this writer's opinion, a curious premise underlies Sagan's conclusion. It is assumed to be easier to get agreement among the nuclear nations about arms reductions than for them to independently change their targeting and strategy so as to continue to deter war by planning to wage it below the threshold.

The following sections explore a different premise: even if the risks of nuclear winter were found to be credible, in the absence of major arms reductions, nuclear nations will not cease relying on the threat of use of nuclear weapons for their security. While the nuclear winter may be a new constraint on strategic planning, adaptations

⁴ Early in the article, Sagan states that "a typical thermonuclear weapon now has a yield of about 500 kilotons" (p. 260). According to the Congressional Budget Office, the mean yield of U.S. bomber-delivered and ballistic missile weapons is 354 kilotons. Mean yield for Soviet ballistic missile warheads is 587 kilotons. The weighted mean of both sides taken together is 444 kilotons, so Sagan's estimate is reasonable. (Calculations based upon weapons yields and estimated 1984 inventories in *Modernizing U.S. Strategic Offensive Forces: The Administration's Program and Initiatives*, Congressional Budget Office, May 1983, pp. 76-87.)

⁵ The term is Sagan's in *op.cit.*, Figure 2, p. 288.

⁶ Sagan, *op. cit.*, p. 280.

limitation of collateral damage as much as does the U.S., so the constraints may burden Soviet operational planning even more. A more careful analysis of this issue would rely on consideration of each side's target bases and collateral damage constraints, which are classified.)

- Preemption with thousands of weapons would be an imprudent act, since it would risk visiting nuclear winter on the attacker as well as the victim. Theoretically, this might: (1) reduce the importance of preemption in Soviet doctrine; (2) reduce Western concerns about ICBM survivability for the short term; (3) enhance the credibility of U.S. limited nuclear options and "first use." This could strengthen both crisis stability and traditional U.S./NATO deterrence policy.
- The use of cities as host bases, and eventual reliance on mobility and concealment to protect strategic forces, are methods the Soviets could employ much more readily than could the United States. To compensate, the U.S. would need to build a dramatic lead in its own capability to collect intelligence on Soviet mobile targets and deny the Soviets analogous intelligence about U.S. targets.

Whether the U.S. or the Soviet Union will in the end reap the greater benefit is impossible to project. These speculations do suggest, however, that notwithstanding Sagan's assertion that nuclear winter increases the imperatives for arms control, it may in fact stimulate the achievement of some of arms control's central goals. Stability in crisis could be enhanced and the destructiveness of war would be further curtailed by belief in nuclear winter.

Far from the rhetoric of the more extreme exponents and critics of TTAPS, acceptance of nuclear winter does not necessarily mandate radical changes in U.S. or Soviet strategic policy. Strategic deterrence, and planning by both sides for a comprehensive strategic *military* campaign, will go on. How the United States takes advantage of--or limits the damage from--nuclear winter will continue to depend on careful policy consideration and planning.

The overall consequence of belief in TTAPS would be to: (a) enhance crisis stability by reducing incentives to preempt; (b) further motivate reductions in weapons yields that have already been occurring, reducing the overall destructiveness of nuclear war, and particularly the threat to civilians; (c) delay, but not eliminate, the enlargement of threats to the survivability of land-based strategic forces and C3I; and (d) severely reduce the scale of nuclear attacks and therefore drastically prolong a nuclear campaign.

The benefits to the U.S. and the Soviet Union differ, and are not clearly symmetric. For example:

- The yields of nuclear weapons and their targeting will probably become more varied as nations attempt to maintain the ability to meet their strategic objectives within the constraints of nuclear winter. "Strategic weapons" might come to also include chemical weapons, conventional weapons, and exotic/low-yield nuclear weapons.¹ The advantages will go to the side with the greatest flexibility, in its forces and its R&D. Soviet throwweight advantages clearly allow them to deploy more of everything--big and small weapons. The U.S. retains an advantage in the flexibility and reusability of its bomber and cruise missile forces.
- The Soviet reserve force would probably have to exert itself more than the U.S. to reestablish a capability to threaten ultimate punishment *in lieu* of widespread direct attacks on cities. However, the additional investment is not likely to be large.
- The ability of the U.S. to credibly threaten a military defeat of the Soviet Union in the event of nuclear war could be greatly degraded, as many key Soviet leadership, C3, and logistical targets are located in or near cities. (Certainly the U.S. has many important military targets in cities as well, and there is little evidence that the Soviets emphasize

¹ As mentioned, these trends are not the exclusive product of concern about nuclear winter.

IV. ASSESSMENT AND CONCLUSIONS

The discussion thus far has suggested that belief in nuclear winter may lead to the following:

- (1) In the near and mid-term, the number of urban areas targeted (including "military" installations in urban areas), would be greatly reduced, with similar diminution of overall physical damage.
- (2) Belligerents would exercise great self-restraint, extending the war in time and (probably) making it less destructive in the aggregate.
- (3) Concerns about keeping attacks below the threshold would limit the size of an attacking wave, greatly reducing the threat of (and incentives for) preemption. (This might be disputable if a single "threshold" could be well-established.)
- (4) Cities would be further displaced as the direct targets of a "final deterrence" reserve force. Greater emphasis would be placed on other forms of "mass destruction," such as chemical weapons, biological weapons, or irradiation.
- (5) Key strategic installations might enjoy a temporary respite (lasting perhaps ten to twenty years) from threats to their survivability if they take advantage of the risk of firestorms (in real or synthetic "cities").
- (6) Eventually, very low-yield warheads would be able to threaten these "cities" without risking nuclear winter. If coupled with burrowing technology, the new weapons would be able to destroy anything that could be found, including deep underground bases. Critical forces and facilities would have to be mobile or well-hidden to survive.
- (7) With these new weapons, the critical limit on the size of attacks would therefore be *information*. Wars would likely remain prolonged because of difficulties locating worthwhile targets. *Information*, not nuclear winter, would become the binding constraint.

simultaneously, attacks will probably be very small (one to perhaps ten weapons per volley). A true "slow-motion" war could last months or years.

The arsenals used in such a war would likely be a curious (by today's standards) mixture of small, highly accurate warheads used to minimize damage in urban areas (real or synthetic) side-by-side with large, "dirty" groundburst irradiation weapons designed to render key real estate uninhabitable (or at least restrict its use). If passive defense preparations were made, it is arguable that casualties might be reduced to a small fraction of those that would be suffered in a war today. But the political consequences of a nuclear war lasting for years, effectively paralyzing economic activity, are imponderable.

After twenty years or so, it could be possible to return to threats against cities as the mission for a reserve force. The weapons to be used might be one or even two orders of magnitude *lower* in yield than their predecessors. This trend to smaller and more accurate weapons has preceded TTAPS, but would be accelerated by the desire to stay below the nuclear winter threshold. While final deterrence might still rest on threats against civilian installations (though the credibility of those threats could remain open to question), and the military campaign would no longer treat cities as sanctuaries, the damage inflicted on civilians would be far less than would be the case today. Whether such a prospect is *more* desirable than the current situation is moot. However, reducing the scale of destruction and the casualties inflicted among innocent bystanders could hardly be considered a bad thing.

C. LONG-TERM IMPLICATIONS

The mid-term possibilities all represent "retrofits" onto existing systems, organizations, and plans. Soon after nuclear winter is recognized, however, R&D would be initiated to field systems designed specifically to meet new missions mandated by nuclear winter.

Over the next twenty years continuing improvements in missile accuracy could permit use of very low-yield weapons with such low CEPs⁵ (Sagan cites 35 meters) that, if coupled with burrowing technology, probably would be able to destroy even very hardened silos and underground command posts.⁶ Such subsurface attacks could be made without much regard for climatic consequences. Dust produced by groundbursts and the extensiveness of fires would both be greatly reduced if yields were decreased to the low kiloton range (1 to 10 kilotons). Similarly, weapons research might aim to produce weapons that minimize the amount of energy produced as heat, in favor of blast, or gamma rays. There is precedent for this in the enhanced radiation weapon (neutron bomb) program.

Best of all would be non-nuclear weapons with accuracies sufficient for strategic missions. The common feature of all these developments is that they were all being pursued before the TTAPS study. Nuclear winter may in some cases accelerate certain R&D by reinforcing the rationale for more discriminating conventional and low-yield nuclear weapons, but that rationale antedates TTAPS.

These improvements would nullify the value of both hardening and city-basing to protect strategic forces and installations. Aside from direct defense, only mobility and concealment might offer any protection. The pace of a war would depend heavily on the potential of each side's intelligence to acquire targets and shoot in time to destroy them. Satellite reconnaissance and associated earth-based control and processing facilities would probably be among the first targets, thus denying both sides much of their target intelligence. Barring some miraculous ability to locate most or all of an adversary's forces

⁵Circular Error Probable, the radius of a circle in which 50% of armed warheads will land. Accuracy improves as CEP diminishes.

⁶ Sagan, *op.cit.*, p. 279.

weapons. The current and projected Soviet advantage in throwweight affords them greater flexibility to both increase weapons yields for some missions, and fractionate and down-size weapons for others.

type might be very foolhardy in peacetime, however, since it would be *designed* to be unsafe. Perhaps the most prudent operational concept for such facilities would be to leave them unoccupied in peacetime (except for minimal security and maintenance personnel) but use them as crisis host locations, to which aircraft, SSBNs, etc., would disperse on strategic warning.

(2) Countermeasures to New Basing Options

Irradiation of cities to deny their use was mentioned in Section III as a substitute for direct attack. It might be easier to attempt the same denial tactic against certain military targets (especially major bases and depots) because of their comparative isolation. Depending upon the radioactivity's persistence, this could be at least partly countered by increased training and preparation for decontamination and operations in a nuclear environment. Military installations, such as airbases, would have to be designed to continue to operate under fallout, with extensive sheltering, medical facilities, and dispersal of critical elements within the base. Since some U.S. bases in the Far West are as many as tens of thousands of square miles in area, it might be quite feasible to protect them against radiological attacks.

(3) Overall Effects on Survivability

These countermeasures suggest that while no specific *single* military target could be guaranteed to survive enemy attack, some large fraction of the U.S. and Soviet target bases (up to hundreds or thousands of facilities on each side) could be prepared so as to dissuade the enemy from attacking them directly, and to thwart his ability to render them inoperable via indirect attack. An attacker's confidence in his prospects for militarily defeating his opponent would thus be significantly diminished. However, the Soviets are likely to have an easier time compensating than the U.S. The two principal means of continuing to threaten these military targets would be radiological attack, using large weapons, or direct attack with small, accurate

by a peacetime accident, yet would be triggered by even a (deliberately) low-yield attacking weapon.

B. MID-TERM IMPLICATIONS

While the changes in planning mentioned above would "make do" with current force postures, after a few years we could expect to see new basing schemes and modifications to existing forces to fully react to nuclear winter. In the midterm, it should be possible to: (1) Rebase forces to take advantage of nuclear winter; (2) Design measures to counter the opponent's rebasing strategy.

(1) New Basing

If attacks against urban targets are greatly circumscribed, there could be a great incentive to base critical forces and installations (e.g., warning, C3, logistics) inside cities, or have contingency plans for moving them there in a crisis. This may seem farfetched, but during the Cuban crisis in October and November 1962, SAC dispersed B-47s and tankers to a number of civilian airports, including those of several major cities, without apparent opposition from nearby. One could envision SSBNs, mobile ICBMs, and mobile or semi-mobile command posts and warning centers flushing from their peacetime main operating bases in a crisis to stand alert inside major urban areas.

An alternative that would be politically less troublesome and possibly less expensive would be to surround existing general purpose force bases, bomber bases, command posts, radar stations, and perhaps ICBM launch control facilities with combustible material of the type and density that would create a city-sized firestorm if attacked by nuclear weapons. In the present environment, this seems implausible. However, if nuclear winter was being taken seriously, there probably would be a significant research program investigating the phenomenology of firestorms, and the extent, persistence, and absorbancy of smoke and soot produced by burning various materials. If it were determined that "nuclear winter"-scale clouds could be generated by a variety of materials and densities, there is a good chance that some of those combinations would be relatively inexpensive to build--perhaps a few tens of millions of dollars per base.⁴ Operating a facility of this

⁴ One of the most expensive components would probably be some sort of control mechanism to insure that the firestorm would not be ignited

(2) Protracted War

Aside from redefining reserve force targets, concern about nuclear winter would force major changes in the targeting of the initial military campaign. One can envision two initiatives: (1) Targeting guidance might severely circumscribe the number of military and military-economic targets inside urban areas to be directly attacked, although "fallout" targeting might be used as a substitute. (2) The size of the attacker's initial wave might be scaled back to limit the risk of smoke and dust exceeding a threshold (perhaps 100 to 500 weapons for a mixed airburst/groundburst counterforce attack on both isolated and urban targets).³ The combination of these effects would greatly reduce the immediate short-term damage of large exchanges. However, because as much as nine-tenths of each side's inventories might remain after the initial exchange, the war could continue for much longer than the one or two-wave "massive" exchanges that are the typical image of central war. Follow-on salvos would have to be delayed until the leadership could have confidence, based on meteorological data, that the "threshold" would not be crossed.

Discussion in the past several years concerning the possibility of a nuclear war becoming "protracted" has generally assumed that "protraction" of the campaign would occur if one side proved to be more resilient than its adversary had expected, thus depriving him of a quick victory. While doctrinal and technical experts disagree about the feasibility and likelihood that a nuclear war can remain limited *today*, nuclear winter may impose the restraint that would *guarantee* protraction in the future. These changed circumstances would favor the side that fields the extensive command, control, communications, and intelligence (C3I), and logistical support to ensure that their strategic forces could continue operating for weeks and months. Arguably, that side is not the United States.

³ It has been suggested that a clearly-defined threshold might create overwhelming incentives to preempt in a crisis. The side that launched an attack could employ weapons just short of the threshold, preventing its opponent from responding until the atmosphere cleared (i.e., weeks or months). However, since the "threshold" *per se* is highly uncertain, this uncertainty could be expected to mitigate quite substantially any pressures to preempt.

attack an adversary's cities might be considered hollow since within weeks after his attack the smoky cloud would extend over the attacker's territory as well. According to Sagan, the attacker would suffer nuclear winter *even if he received no attack in response*.

This would probably complicate targeting of its withheld reserves for the Soviets more than for the U.S., since it is difficult to conceive of any alternative target sets that would frighten the U.S. quite as much as cities. Especially "dirty" weapons ground burst upwind of concentrations of population might be substituted, if the ground zeros could be located in areas with low densities of flammable materials.² Such a tactic would require considerable real-time intelligence on wind patterns in the target area. Because U.S. cities are surrounded by much more extensive suburbs than Soviet cities, it would be marginally more difficult for the Soviets to find appropriately isolated ground zeros. It probably would not be *much* more difficult. If the Soviets needed to set their DGZs substantially farther upwind to cover U.S. city centers while avoiding populated suburbs to minimize the risk of firestorms, they could compensate by using weapons of higher yield, or by increasing the number of weapons per city. Neither method would be especially expensive. As mentioned in Section II (footnote 4), Soviet warheads have an average yield that is nearly double average U.S. yields. Even if the number of weapons to meet a hypothetical Soviet Secure Reserve Force requirement was substantially larger than the analogous U.S. requirement, it would still mean (at most) a few hundred more weapons out of an inventory of more than 7000. As alternatives or complements, potential reserve force target sets might include agriculture (via irradiation and direct attacks on grain storage facilities) and national leadership (possibly including "barrage" attacks against mobile command posts).

Union can maintain an "assured destruction" reserve after even the most severe counterforce attack, threats against cities are considered by many to be immoral or irrational and therefore already not very prudent (or credible). In this view, nuclear winter only buttresses the mutual counter city deterrence already extant.

² Clearly such a tactic has some severe disadvantages. It is presented to suggest how nations could retain a policy of threats against cities and populations (regardless of its credibility) in the interim until force structures could fully adapt to nuclear winter.

- (1) It will severely limit attacks on targets that might result in major fires. As these are clearly the riskiest targets for attacks of any scale, few would probably be attacked.
- (2) It will greatly limit the number of weapons launched at one time. Conservative national decisionmakers would probably choose to limit the attack to the low end of Sagan's estimate (or lower), no more than a few hundred warheads or less than 100 megatons.

Turco's article suggests that the temperature effects of any given attack would begin quite rapidly, with the temperature low point occurring one to four weeks after the attack. Precipitation of particulates to return temperatures to normal could take two months or longer. All sides in a potential nuclear war could be expected to exploit meteorological intelligence to assess the state of the atmosphere and estimate the likely consequences of additional attacks.

A. NEAR-TERM IMPLICATIONS

The two immediate effects of the threat of nuclear winter are: (1) Elimination of direct attacks on cities as a mission for reserve forces; (2) great reductions in the scale of each phase of the military campaign, extending the length of a potential war.

(1) Reserve Force Missions

Final deterrence of attacks against non-combatants has for the United States rested upon the ability to maintain a reserve of strategic weapons, withheld during the countermilitary campaign, that could be used against some target of ultimate value to the Soviet Union or other adversary. Since the 1960's it has been presumed that submarine-launched ballistic missiles could be withheld from the Single Integrated Operations Plan (SIOP) to threaten Soviet industrial and economic recovery targets, which are principally located in or near cities. At the very least, nuclear winter would require reconsideration of targeting the Secure Reserve Force (SRF) in this way.¹ Tacit threats to

¹ In an era where by most estimates both the U.S. and the Soviet

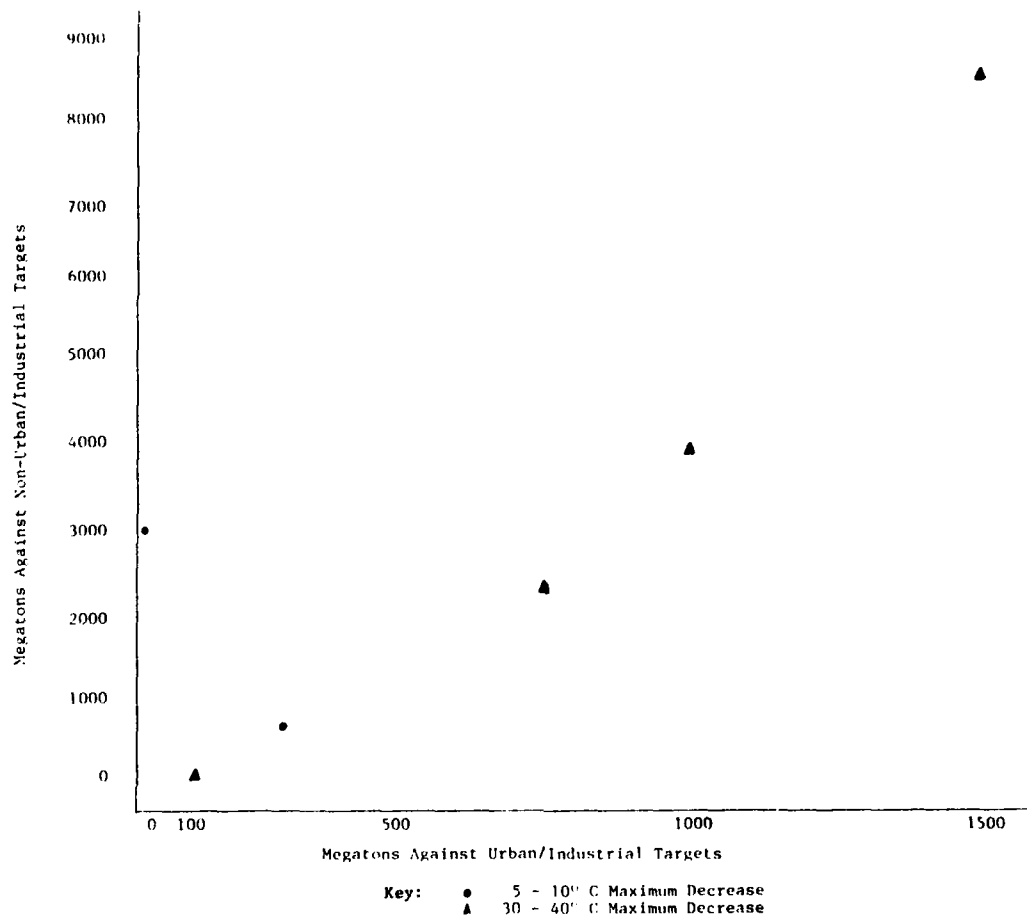


Fig. 2--Temperature Effects of
Varying Attack Mixes as Reported in Turco, et. al.

III. PLANNING FOR FUTURE WAR BELOW THE NUCLEAR WINTER THRESHOLD

Sagan's designation of a "rough threshold" has two dimensions: (1) in numbers, something on the order of 500 to 2,000 warheads in the sub-megaton range; (2) in employment, the risks of nuclear winter rise with the fraction of weapons employed against flammable targets (chiefly cities). "Threshold" may, of course, be an inaccurate description. Presumably the risks of substantial decreases in temperature are fairly continuous, being at their lowest for attacks with small numbers of weapons on isolated targets and rising with both numbers and the fraction allocated to urban/industrial areas.

While it would be desirable to estimate the nature of this presumed continuous function and the tradeoff between urban-industrial warheads and others, it is difficult to do so from the published data. Figure 2 displays the targeting mix of the cases reported in Turco's *Science* article for which temperature effects data were shown. The effects of these attacks fell into two groups: those where the maximum temperature drop produced was in the 5-10 degrees Celsius range, and those where the maximum decrease was 30-40 degrees C. If each urban-industrial warhead had the effect of some larger number of non-urban warheads, then a concave or negatively sloped tradeoff surface, such as that suggested by the two attacks which caused 5-10 degree C drops, would be expected. However, the more severe case reveals nothing like this sort of shape. Therefore, identification of a specific threshold or the path to reach it will have to await publication of additional data.

This section describes possible strategies for fighting future war below the "threshold." Obviously the "threshold" must be defined loosely, given the contrasting impressions furnished by Sagan's "500 to 2,000 warhead" estimate versus the data in Figure 2. For the purposes of this paper, the loose threshold will be assumed to affect strategic planning in the following two ways:

will evolve slowly. For at least the next five or ten years strategy will be rooted in current forces, doctrine, and plans. This portrait of the future is used as a basis for discussing the abilities of the U.S. and the Soviet Union to adapt their strategies to nuclear winter.

In this respect, the U.S. government's implementation of President Reagan's strategic defense initiative is instructive. In recognition of the very long lead times associated with development of defensive technologies, some analysts (in particular the Hoffman Panel) undertook a policy review that of necessity was "conditional." (That is, it assumed that predictions of the capabilities of proposed technologies were true for the purposes of the study.) Similarly, the policy community could perform an important service by formulating a research agenda for nuclear winter under similar "conditional" ground rules. One of the more persuasive arguments in favor of vigorous R&D in defenses is to be prepared in the event of a Soviet breakthrough. By the same argument, it would be foolish to allow the Soviets a monopoly of understanding of the climatic effects of nuclear war.

Physical research and development should include examinations of the meteorological intelligence required to assess real-time climatic effects of nuclear use; research into potential mitigation or countermeasures to reduce the smoke produced by fires from nuclear explosions; and physical experiments. Policy research should emphasize acquiring an estimate of the true state of Soviet understanding of climatological issues; an evaluation of U.S. and Soviet force planning alternatives; and a consideration of what effect, if any, nuclear winter might have on the planning of smaller nuclear powers.

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